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METABOLIC ENGINEERING OF MICROBES TO SUPPORT HUMAN SPACE EXPLORATION IN THE POST-GENOMIC ERA

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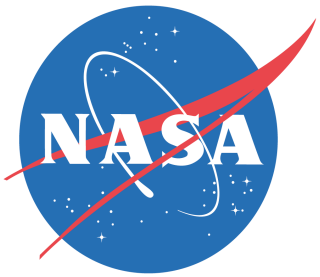
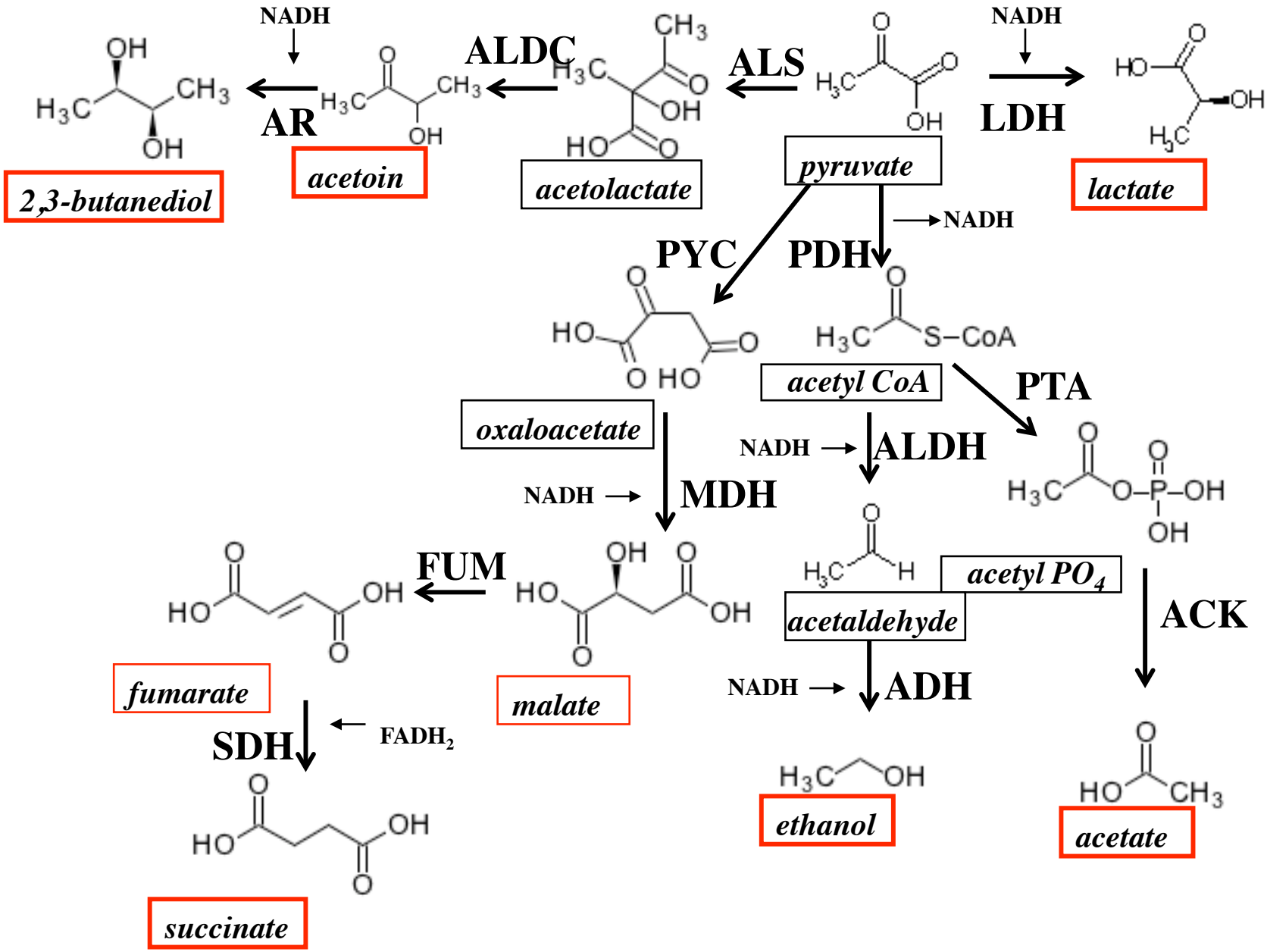


Any self-sufficient modern society will need a robust, sustainable chemical inventory

- Most complex chemicals, plastics, and pharmaceuticals are made from a relatively small number of simpler feedstock chemicals.
- Examples: ethanol, isopropanol, *n*-butanol, 2,3-butanediol, acetic and lactic acids, etc.
- These can all be manufactured by microbes *in situ* from fixed CO_2, carbon-containing waste materials, etc.

Mixed-Acid Fermentation Pathways (Example: *B. subtilis*)



Compound	C#	Uses:
CO_2	1	C-source for plants; chem. Feedstock; solvent
Formate	1	Electronics; mini-fuel cells; de-icer; natural pesticide
Acetate	2	Chem. Feedstock; solvent; acid; plastics (esters)
Acetaldehyde	2	Chem. Feedstock; solvent; pharmaceuticals
Ethanol	2	Chem. Feedstock; fuel; antiseptic; boredom reliever
Pyruvate	3	Important precursor to many chemicals
Lactate	3	PLA (biodegradable plastic), foods, detergents
Acetoin	4	Precursor to 2,3-BD; flavor enhancer (“butter”)
2,3-butanediol	4	Chem. Feedstock (solvent, , fuel additives, MEK, 2-butanol; synthetic rubber, various plasticizers)
Malate	4	Food additive (tart, sour)
Fumarate	4	Food additive (sour); food coagulant; polyester resins; mordant for dyes
Succinate	4	Beverage flavor (salt, bitter, acid); excipient in pharmaceutical products